REMARKS

Claims 1-26 are pending in the present application. In the Office Action mailed March 9, 2005, the Examiner rejected claims 1-6, 8, and 19-22 under 35 U.S.C. §102(b) as being anticipated by Kuhara (USP 4,859,946). The Examiner next rejected claims 1-5, 7-8, and 23-26 under 35 U.S.C. §102(e) as being anticipated by Zhang (US Pat. App. Pub. 2003/0109781 A1). Claims 11-14 and 16-18 were rejected under 35 U.S.C. §102(b) as being anticipated by Maier et al. (USP 5,451,876). Claims 1, 9, and 10 were rejected under 35 U.S.C. §103(a) as being unpatentable over Maier et al., and further in view of Zhang. Before responding substantively to the Examiner's rejections, it is noted that the title patentee of USP 5,451,876 is "Sandford et al." rather than "Maier et al." as referenced by the Examiner. Therefore, for purposes of responding to the outstanding rejections, reference will be made to "Sandford et al." rather than "Maier et al.".

Regarding the objection to the drawings, formal drawings are being submitted under separate cover.

Regarding the objection to claims 2, 4, and 7, Applicant refers the Examiner to the amendments made above which are believed to correct the informalities identified by the Examiner.

The Examiner rejected claims 1-6, 8, and 19-22 under 35 U.S.C. §102(b) as being anticipated by Kuhara. Applicant respectfully disagrees.

Kuhara teaches a magnetic resonance imagine system whereby "a correcting unit substantially corrects generation timing errors of the echo signals in the imaging mode based on the peak position" of a series of echo signals. Kuhara, Abstract. To improve the detectability of the peak of an echo signal, Kuhara teaches application of a pulse sequence without phase encoding. See col. 5, lns. 19-22. Kuhara teaches that peak detection is important for image reconstruction because "in order to accurately reconstruct an image, peak positions of absolute values (to be briefly referred to as peak positions hereinafter) of echo signals must be equidistantly located." Col. 2, lns. 17-20. "If the peak positions are not equidistantly located, it is impossible to accurately sample and acquire the echo signals and to reconstruct an optimal image." Col. 2, lns. 20-23. Kuhara further teaches that equidistance between peak conditions is often lost in light of

the switching waveform of readout gradients not being an ideal rectangular waveform. See col. 2, lns. 35-37. Accordingly, Kuhara teaches the aforementioned peak detection technique such that if a "non-sharp waveform of read gradient field Gr" is detected, "the sampling position can be shifted in the Fourier space for correction in accordance with the detection data." Col. 5, ln. 67 – col. 6, ln. 2. That is, "even if peak position deviations of the echo signals occur due to the non-sharp waveform of read gradient Gr or any other cause, accurate image reconstruction can always be performed using the echo signal sampling data (acquired without phase encoding) with respect to the peak positions as centers." Col. 5, lns. 48-53, (parentheses added). One skilled in the art would readily appreciate that the technique disclosed by Kuhara is a peak detection technique and not a technique that corrects for amplitude modulation effects in a fast spin echo sequence after data acquisition.

Before addressing claims 1-6, 8, and 19-22, Applicant believes it beneficial to summarize the subject matter of the claimed invention. In the context of MR data, amplitude modulations effects materialize as a result T2 decay or generation of stimulated echoes. As set forth in the instant application, amplitude modulation can modify the point spread function along the phase-encoding direction and thus impact the reconstructed image. Moreover, if the amplitude modulation is characterized by significant high frequency components then image ghosting can occur. As set forth in the application, the claimed invention is directed to a method and apparatus to reduce the impact of amplitude modulation effects. In one exemplary embodiment, reference data is acquired without phase encoding and is indicative of the maximum achievable signal that a phase encoding acquisition may attain. From this reference data, a correction table is generated and is used to correct acquired phase encoded MR data. This is in stark contrast from that taught by Kuhara.

Kuhara, as set forth above, is directed to a technique to improve peak detection. It is not directed to the correction of amplitude modulation effects in acquired MR data. Kuhara teaches the acquisition of non-phase encoded data, but Kuhara is explicit that this acquisition to improve the detection of echo signal peak. Kuhara teaches that peak detection can be difficult in echo planar imaging wherein phase encoding gradients are

implemented. As such, Kuhara teaches a system whereby non-phase encoded data is acquired, echo signal peaks detected, and data acquisition controlled accordingly. Not only does Kuhara not teach a technique for correction of amplitude modulation effects, Kuhara neither explicitly nor implicitly makes reference to amplitude modulation effects. Contrary to the conclusion of the Examiner, the difference between positive and negative amplitude values of echo peak position is not an amplitude modulation effect. Kuhara's teaching of positive and negative amplitude values is in reference to the peak of an echo following a positive gradient Gr+ and to the peak of an echo following a negative gradient Gr-, respectively, as illustrated in Figs. 6 and 7.

Accordingly, it is believed that claim 1 is patentably distinct from that taught by Kuhara. Claim 1 calls for the correction of amplitude modulation effects. As set forth above, Kuhara is directed to echo peak detection and neither teaches nor suggests correction of MR data for amplitude modulation effects after data acquisition. Similarly, claim 19 is directed to subject matter neither taught nor suggested by Kuhara. Claim 19 calls for the modification of phase encoded MR data by non-phase encoded MR data to correct for amplitude modulation between multiple echoes. Kuhara teaches a system and method for detecting echo peaks that utilizes non-phase encoded data – not correction of data for amplitude modulation effects. As such, Applicant believes claims 1-6, 8, and 19-22 to call for subject matter patentably distinct from that taught by Kuhara. Allowance thereof is requested.

The Examiner next rejected claims 1-5, 7, 8, 19, and 23-26 as being anticipated by Zhang. Zhang teaches a sequence preconditioning technique for ultra-fast MR imaging. More particularly, Zhang teaches a system wherein "sequence-preconditioning parameters are [sic] used to modify [an] MRI pulse sequence for obtaining diagnostic images in [an] EPI system." <u>Zhang, ¶25</u>. That is, Zhang teaches a technique that sequence-conditioning parameters are determined and "used to precondition the imaging sequence so that the EPI echoes are optimally positioned." Zhang, ¶43.

In contrast, claim 1 calls for correction of <u>amplitude modulation effects</u> in a <u>fast spin echo</u> pulse sequence <u>after data acquisition</u>. First, Zhang neither teaches nor suggests correction for amplitude modulation effects. Second, a fast spin echo sequence (FSE) is

not equivalent to an echo planar imaging (EPI) sequence. An echo planar sequence is characterized by a slice selective RF pulse which is applied in conjunction with a slice selection gradient. An initial phase encoding gradient pulse is applied as is an initial frequency encoding gradient pulse to position the spins at the corner of k-space. Next, an inversion pulse is applied. The phase and frequency encoding directions are then cycled so as traverse k-space. In contrast, a FSE pulse sequence is characterized by a slice selective RF pulse that is applied in conjunction with a slice selection gradient. A series of inversion pulses are played out in conjunction with slice selection gradients and varying phase encoding gradients to sample an echo train. While FSE and EPI are similar in that data acquisition is expedited through the sampling of multiple echoes, one skilled in the art would readily appreciate the distinctions therebetween.

Third, Zhang teaches conditioning of a pulse sequence prior to data acquisition. Claim 1, however, calls for correction of amplitude modulation effects after data acquisition. Zhang teaches a technique that conditions an EPI sequence prior to data acquisition so that echo signals are reasonably well-positioned. Zhang neither teaches nor suggests a post-data acquisition correction or any kind; let alone, amplitude modulation effect correction.

Claim 19 calls for the modification of phase encoded data by non-phase encoded data. As set forth above, Zhang neither teaches nor suggests modification of data. Zhang teaches preconditioning a pulse sequence prior to data acquisition. Moreover, Zhang teaches a technique to ensure that echoes are well-positioned for post-acquisition correction. In this regard, Zhang also fails to teach or suggest correcting for amplitude modulation effects. As such, Zhang fails to teach or suggest that called for in claims 1-5, 7, 8, 19, and 23-26.

Claims 11-14 and 16-18 stand rejected as being anticipated by Sandford et al. The reference is directed to an MRI system with dynamic receiver gain. In this regard, Sandford et al. discloses an imaging technique wherein an attenuation signal "is employed to dynamically adjust the receiver gain (of an RF coil) during a scan..." Sandford et al., col. 4, lns. 43-45. In this regard, prior to image reconstruction, MR signals are adjusted to normalize out the differences in amplitude and phase caused by

changing receiver gain settings. See Sandford et al., col. 2, lns. 7-9. Accordingly, a "resulting stream of digitized I and Q values of [sic] received signal[s] are output through backplane 118 to the memory module 160 where they are normalized in accordance with the present invention and then employed to reconstruct an image." Sandford et al., col. 4, lns. 58-64. This "normalization" advantageously "insures that the relative amplitude of the NMR signals employed to reconstruct an image are maintained and they each contribute accurately to the reconstructed image." Sandford et al., col. 5, lns. 10-14.

The "normalization" technique is clearly carried out, not for amplitude modulation effect correction, but for adjusting the amplitude of MR signals that were acquired with receivers whose receiver gain settings were varied during data acquisition. To insure an equal contribution of the acquired signals to the reconstructed image, the MR signals are normalized. In this regard, image data from MR signals acquired with a greater receiver gain does not overwhelm data from MR signals acquired with a lesser receiver gain. One skilled in the art would readily recognize that this "normalization" technique is not directed to correcting for amplitude modulation effects. Moreover, the stored receiver gain settings do not amount to a table of amplitude modulation correction values. That is, the gain settings are used to normalize signals as a result of variations in signal magnitude. The gain settings do not correct for amplitude modulation effects. One in the art would readily appreciate the distinction.

Accordingly, Sandford et al. fails to teach or suggest that which is called for in claims 11-14 and 16-18. Allowance thereof is therefore requested.

Claims 1, 9, and 10 were also rejected under 35 U.S.C. §103(a) as being unpatentable over Sandford et al. and Zhang. As described above, however, neither reference teaches or suggests that purported by the Examiner. Zhang teaches a sequence preconditioning technique for ultra-fast MR imaging. Sandford et al. teaches a receiver gain normalization technique. One skilled in the art would readily appreciate that the combination of the references neither teaches nor suggests that which is called for in claims 1 and 9-10. Moreover, the Examiner has not established that one skilled in the art would be motivated to combine the teachings of the references. Given the divergent subject matter of the references, Applicant believes that such a motivation or suggestion

is not present in the references themselves and the Examiner's combination is based, at best, on impermissible hindsight and is more reflective of simply combining references based on a keyword search rather than actual reference teachings.

In sum, the references, neither singly nor in combination, teach nor suggest acquiring MR data with a FSE pulse sequence and correcting for amplitude modulation effects after data acquisition. Zhang not only fails to teach a FSE pulse sequence, but also teaches preconditioning of a pulse sequence rather than post-acquisition correction. Sandford et al. is directed to receiver gain normalization. Neither reference teaches or suggests correction of amplitude modulation effects. In short, the combination of references neither teaches nor suggests that which is claimed. As such, Applicant believes claims 1, 9, and 10 call for subject matter patentably distinct from that taught and/or suggested by the art of record.

Therefore, in light of at least the foregoing, Applicant respectfully believes that the present application is in condition for allowance. As a result, Applicant respectfully requests timely issuance of a Notice of Allowance for claims 1-26.

Applicant appreciates the Examiner's consideration of these Amendments and Remarks and cordially invites the Examiner to call the undersigned, should the Examiner consider any matters unresolved.

Respectfully submitted,

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